

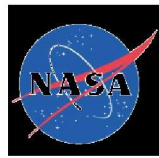


LOX Tank Helium Removal for Propellant Scavenging

Dr. David J. Chato

Abstract:

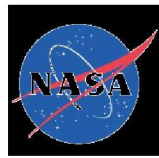
System studies have shown a significant advantage to reusing the hydrogen and oxygen left in these tanks after landing on the Moon in fuel cells to generate power and water for surface systems. However in the current lander concepts, the helium used to pressurize the oxygen tank can substantially degrade fuel cell power and water output by covering the reacting surface with inert gas. This presentation documents an experimental investigation of methods to remove the helium pressurant while minimizing the amount of the oxygen lost. This investigation demonstrated that significant quantities of Helium (>90% mole fraction) remain in the tank after draining. Although a single vent cycle reduced the helium quantity, large amounts of helium remained. Cyclic venting appeared to be more effective. Three vent cycles were sufficient to reduce the helium to small (<0.2%) quantities. Two vent cycles may be sufficient since once the tank has been brought up to pressure after the second vent cycle the helium concentration has been reduced to the less than 0.2% level. The re-pressurization process seemed to contribute to diluting helium. This is as expected since in order to raise the pressure liquid oxygen must be evaporated. Estimated liquid oxygen loss is on the order of 82 pounds (assuming the third vent cycle is not required).



LOX Tank Helium Removal for Propellant Scavenging Test

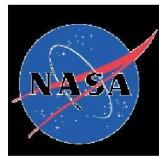
Dr. David J. Chato

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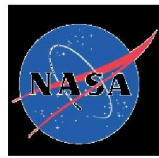
Introduction:

- Helium used to pressurize the oxygen tank since this produces significantly lighter gas residuals at stage burn-out.
- Helium substantially degrade fuel cell power and water output
- This experiment investigates methods to remove maximum amount of helium pressurant while retaining the maximum amount of the oxygen residuals.



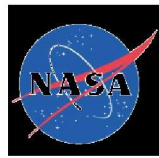
Objectives

- Understand the amount of residual helium in LOX tanks after landing
- Demonstrate the ability to remove the majority of the helium via venting without losing significant quantities of oxygen
- Measure the oxygen/helium content of the remaining gases as they would be sent over time to the fuel cell system



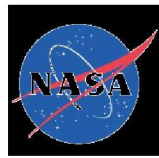
Approach

- Thermodynamic analysis of the system processes will be performed to predict expected helium concentrations before and after various venting scenarios.
- Ground testing will be conducted to validate the analysis predictions and correct the analysis. Tests will be conducted at SMiRF at GRC.



Test Tank in Handling Fixture





Temperature Diode Location

Table 1 Broad Range Diode Rake

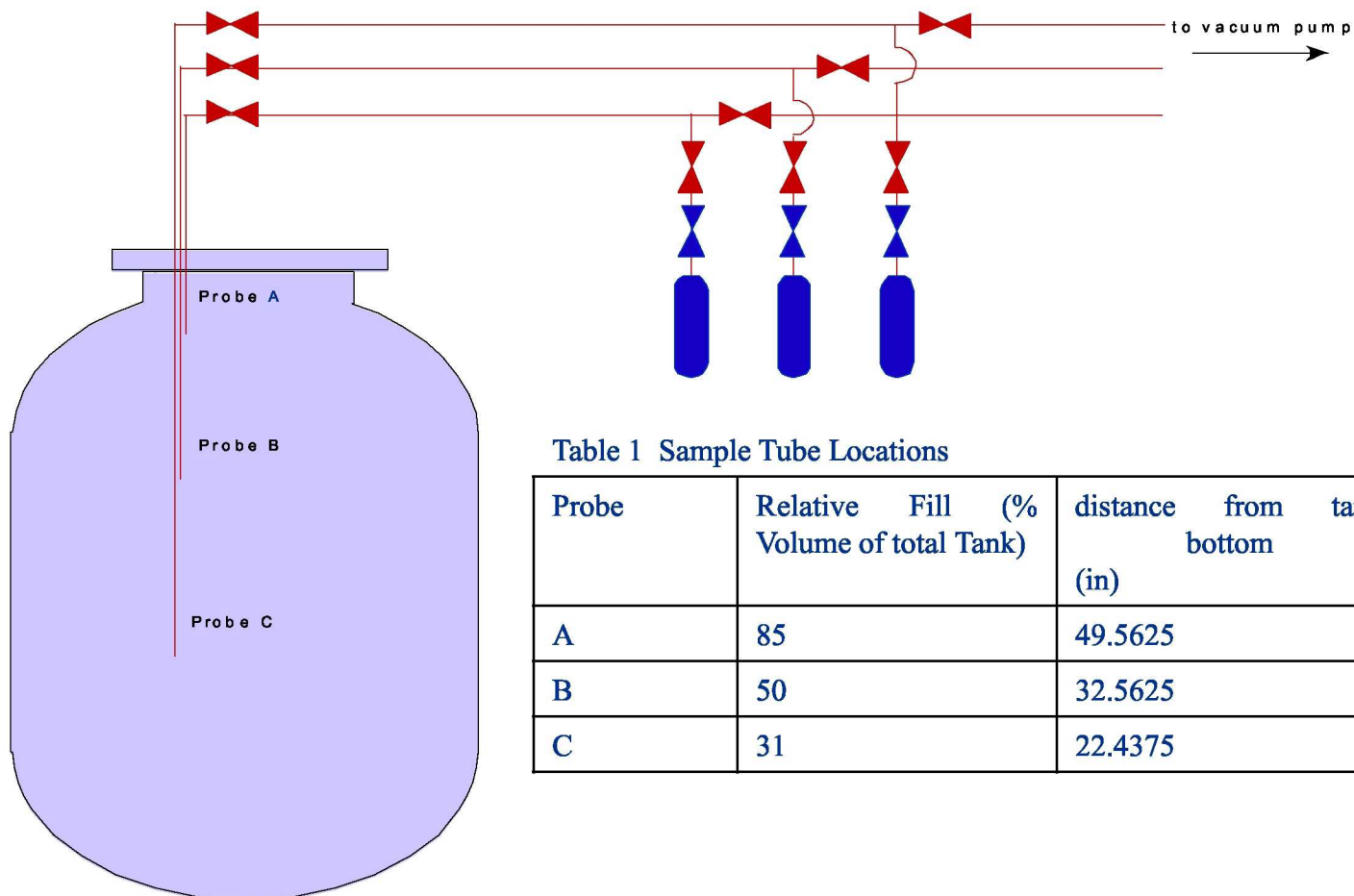
Relative Fill Volume of Total Tank*	Height from bottom of tank (in)	Distance from datum* (in)
5%	6.35	61.21
10%	9.57	57.99
20%	15.32	52.24
30%	21.03	46.53
40%	26.75	40.81
50%	32.47	35.09
60%	38.19	29.37
70%	43.91	23.65
80%	49.63	17.93
90%	55.51	12.05
95%	59.41	8.15

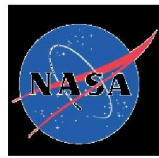
Table 2 Close Rang Diode Rake

Relative Fill Volume of total Tank)	Mean from datum (in)	Height from Tank Bottom (in)
30%	46.5	21.5625
		21.3125
		21.0625
		20.8125
		20.5625
		20.3125



Gas Sample System



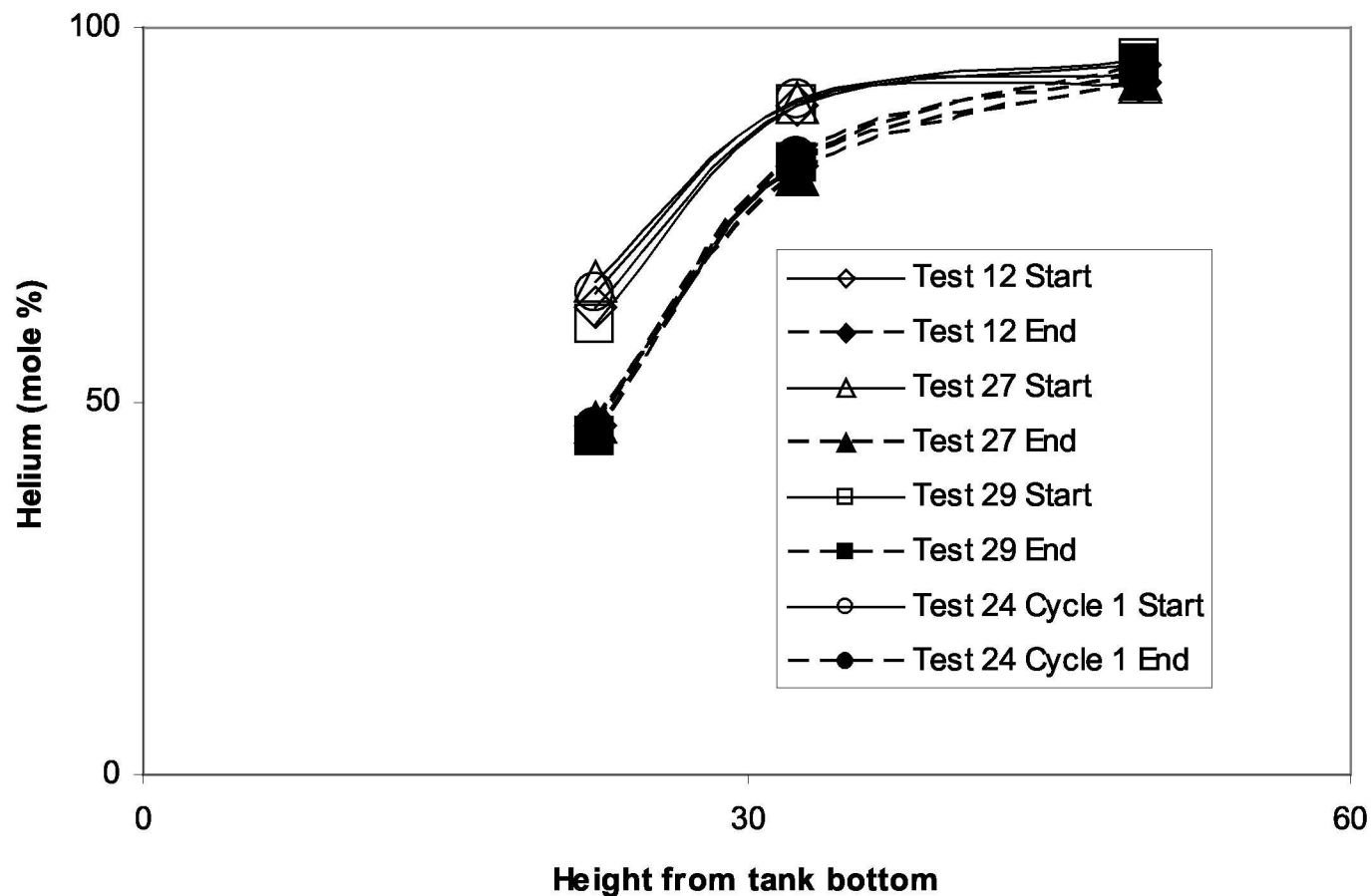


Tests Completed

Test ID Number	Starting Pressure (psia)	Ending Pressure (psia)	Notes
8	50	20	Liquid Nitrogen Checkout
12	50	20	
18	100	20	Gas sample data not available
21	150	20	
24	50	20	Cyclic vent Three vents total
27	50	20	
29	50	20	Direct vent, No gas sample holds

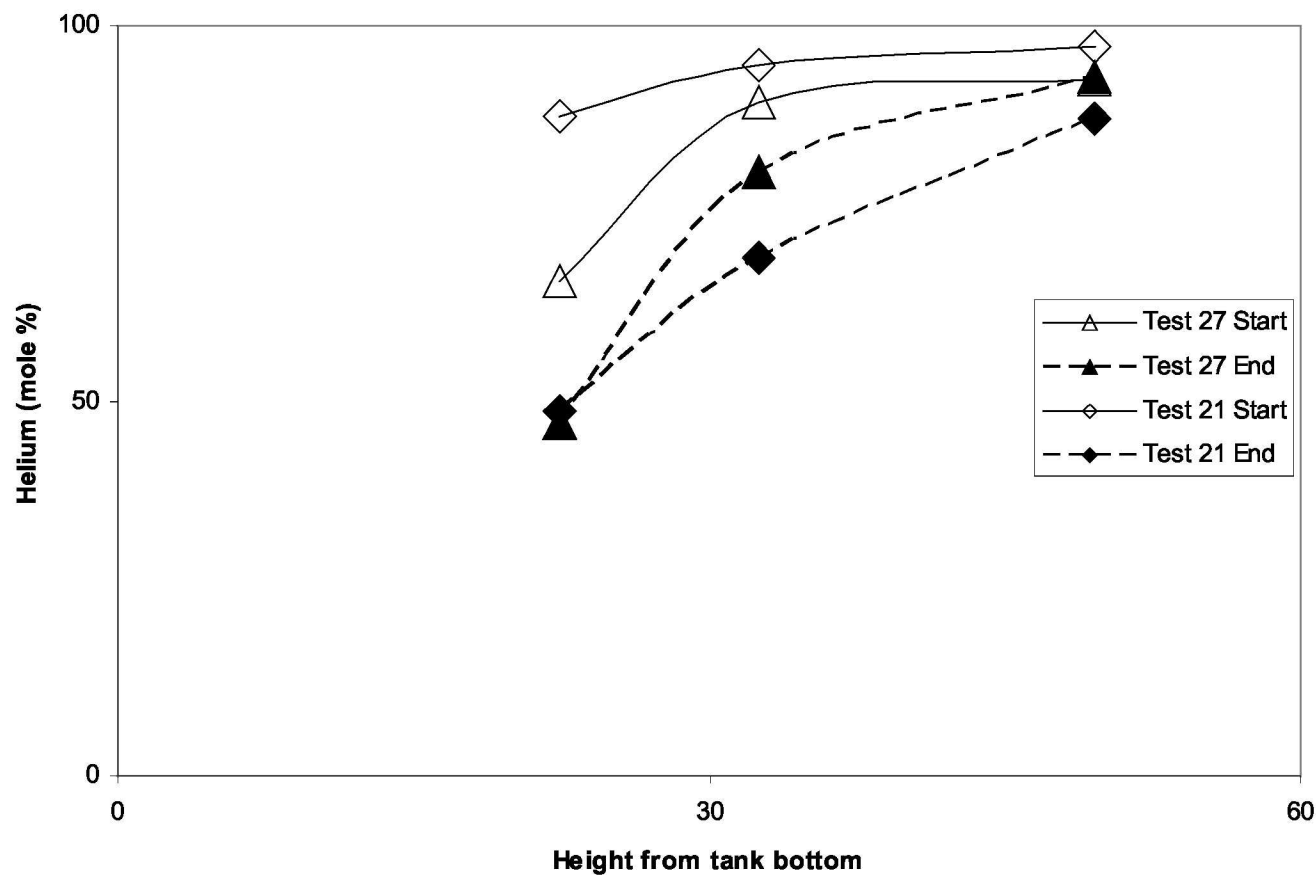


Test Results for Vents from 50 psia



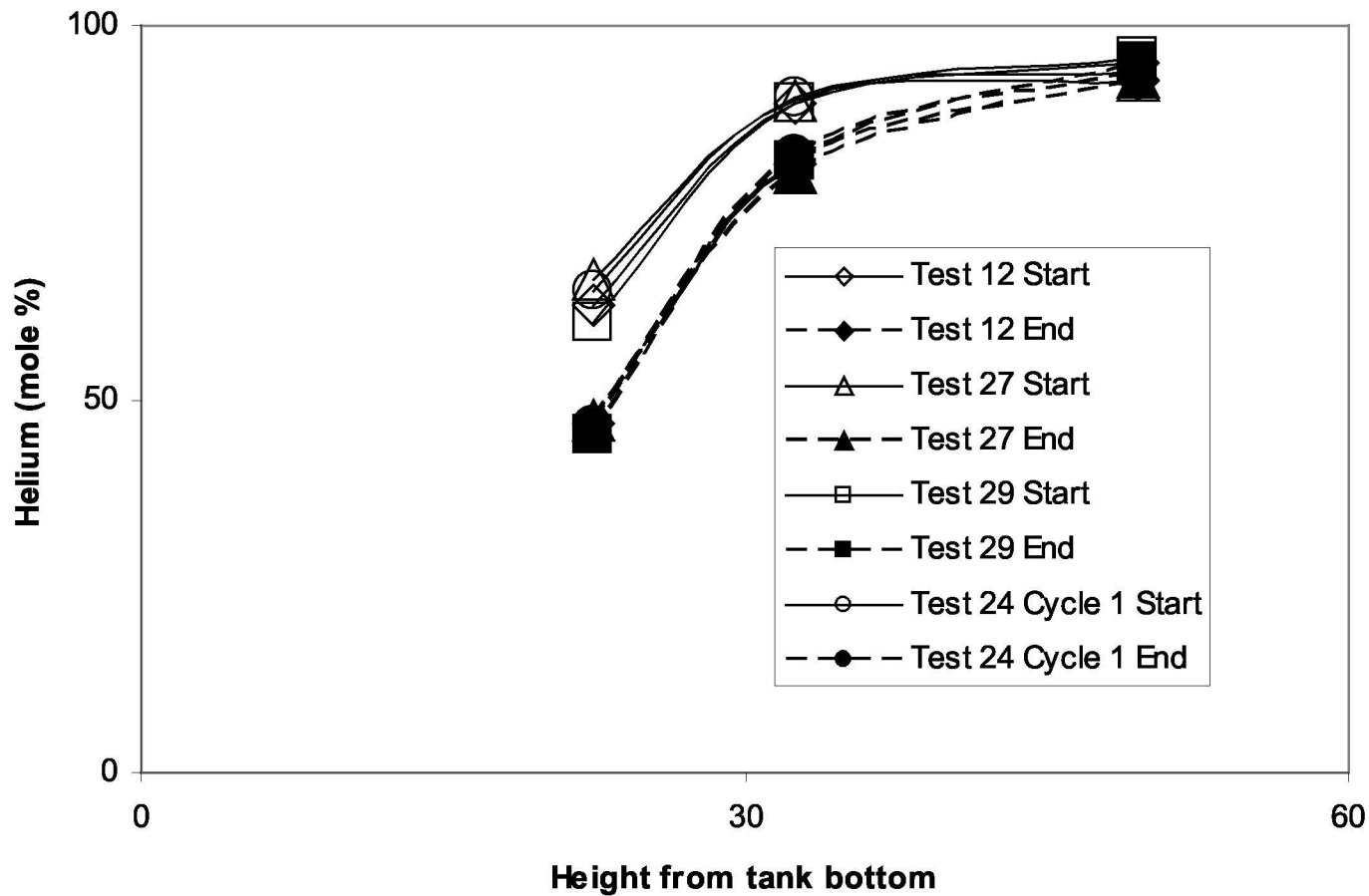


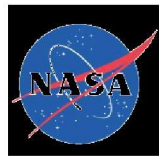
Test Comparison for Vents from 50 psia and 150 psia



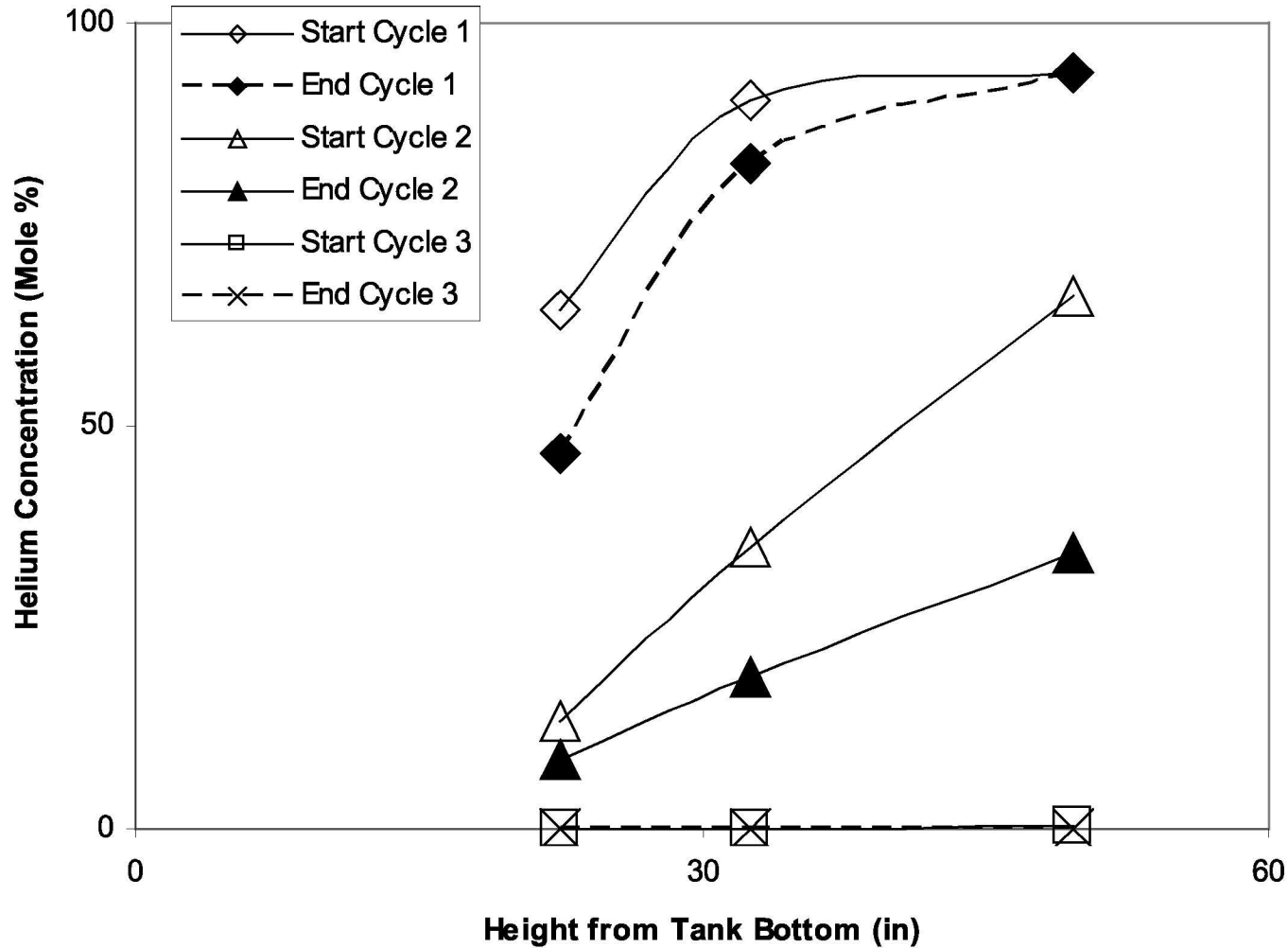


Test Results for Vents from 50 psia



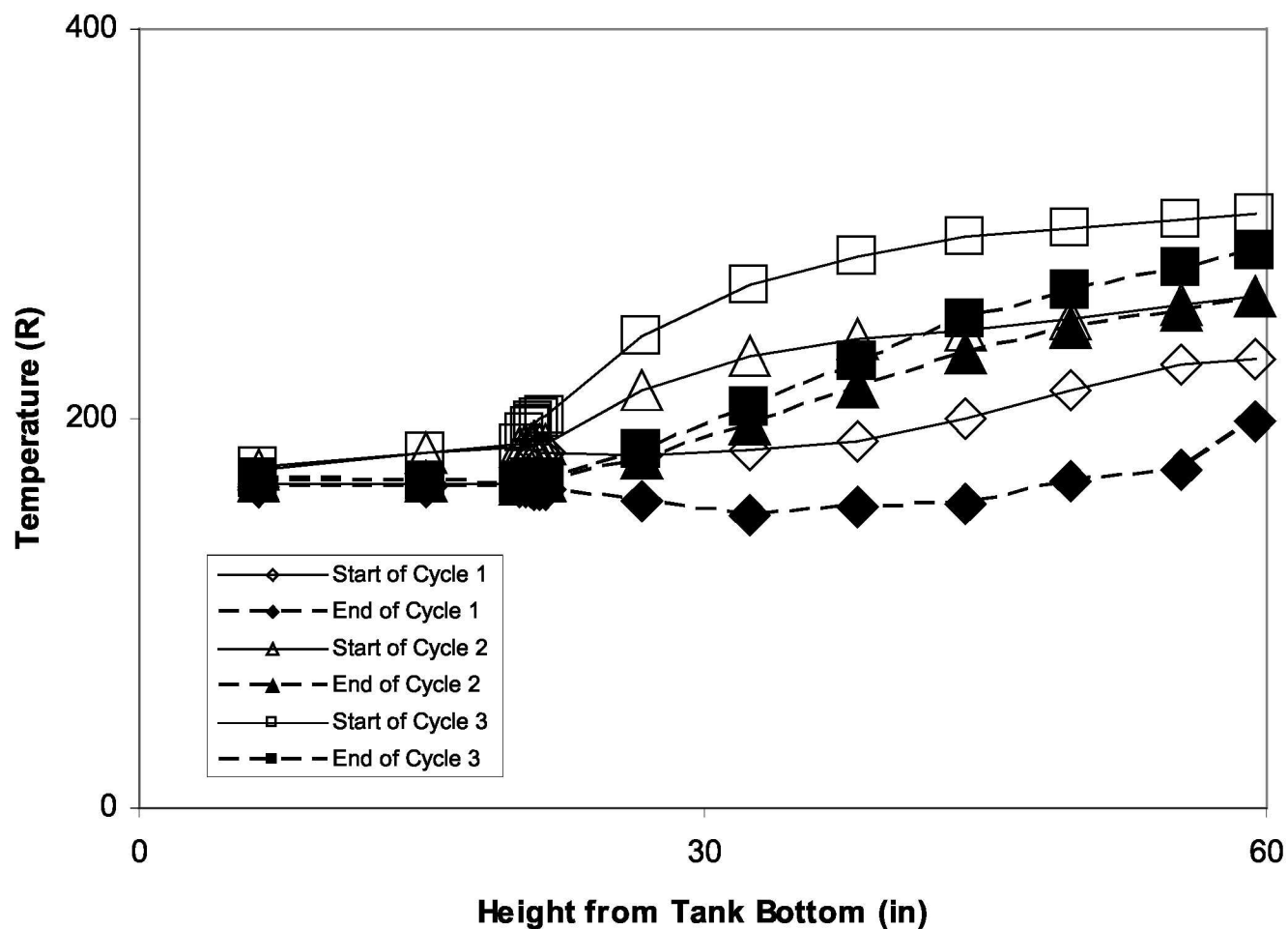


Test Results for Three Cycle Vent Test



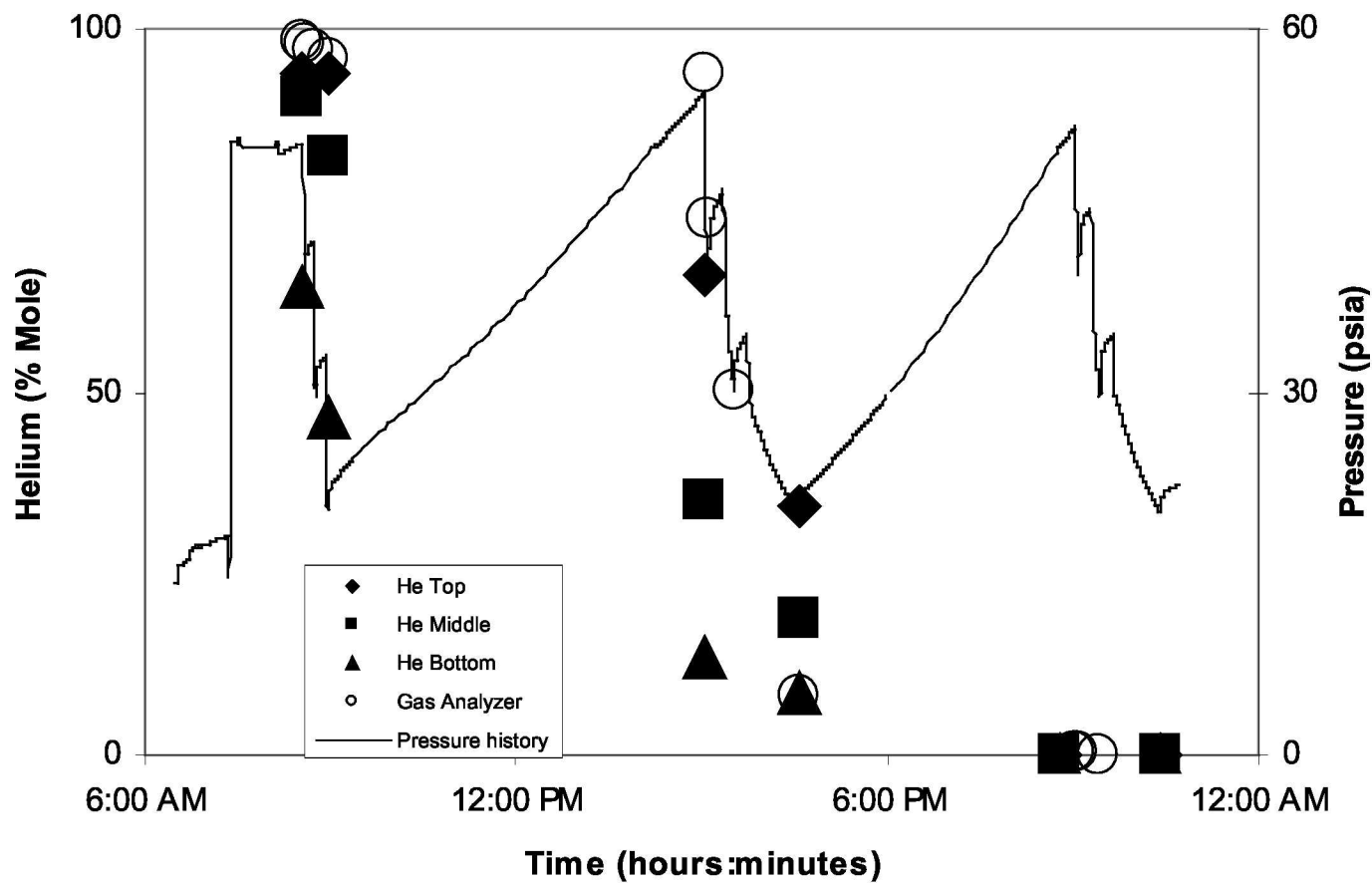


Temperature Profiles During Three Cycle Vent





Time History of Three Cycle Vent





Preliminary Results

- Significant ($>90\%$) Helium is found in the tank after draining
- Although a single vent cycle reduces the helium large quantities remain
- Three vent cycles are sufficient to reduce the helium to small ($<0.2\%$) quantities
- Repressurization seems to contribute to diluting helium
- Propellant loss estimated at 82 lbm assuming third vent cycle is not required